Imaging -Research Directions Sensors and Sources

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Philosophy

- Imaging in the past = radiological diagnosis
- Imaging in the future = obtaining information on tissue biology, in disease and health
  - Broader group of users within biomedicine
  - Different modalities complement each other - can/should be fused
  - To be useful not all imaging has to be
    - 3D
    - Non-invasive
    - High spatial resolution
  - Animal studies esp. genetically altered mice, will push technical ideas - these may then inform and affect human imaging systems

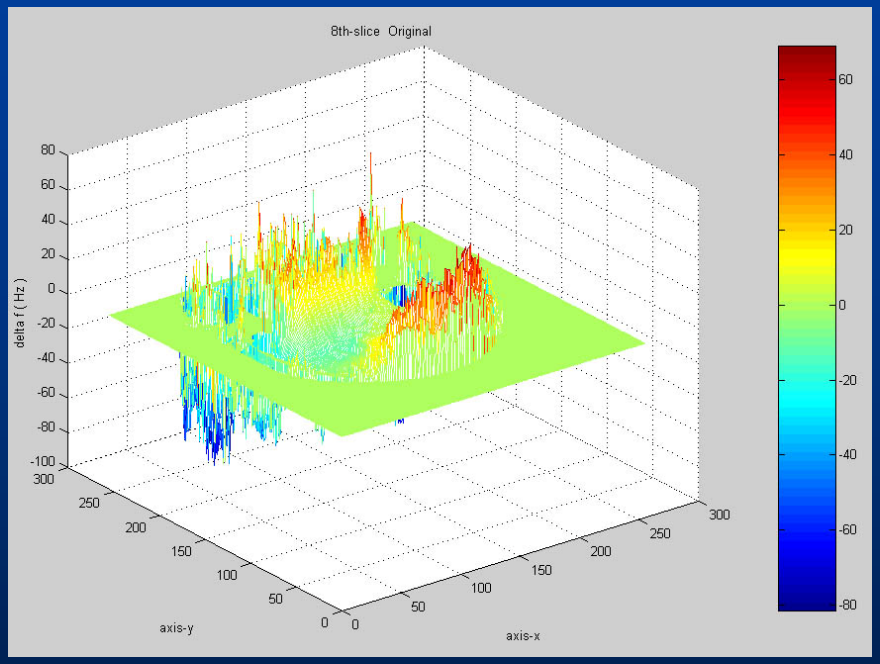
Magnetic Resonance Imaging

- New technical developments can be led by *understanding the nature of the information available (E.g. fMRI)*
- Factors affecting NMR properties still poorly understood (in detail)
  - Physical and physiological factors
  - Relaxation, Diffusion, BOLD, MT, Order (MQC), other properties - what do these tell us? *No quantitative models to explain tissue NMR properties*
  - Biological basis of imaging - connection of *biophysics* to *imaging*

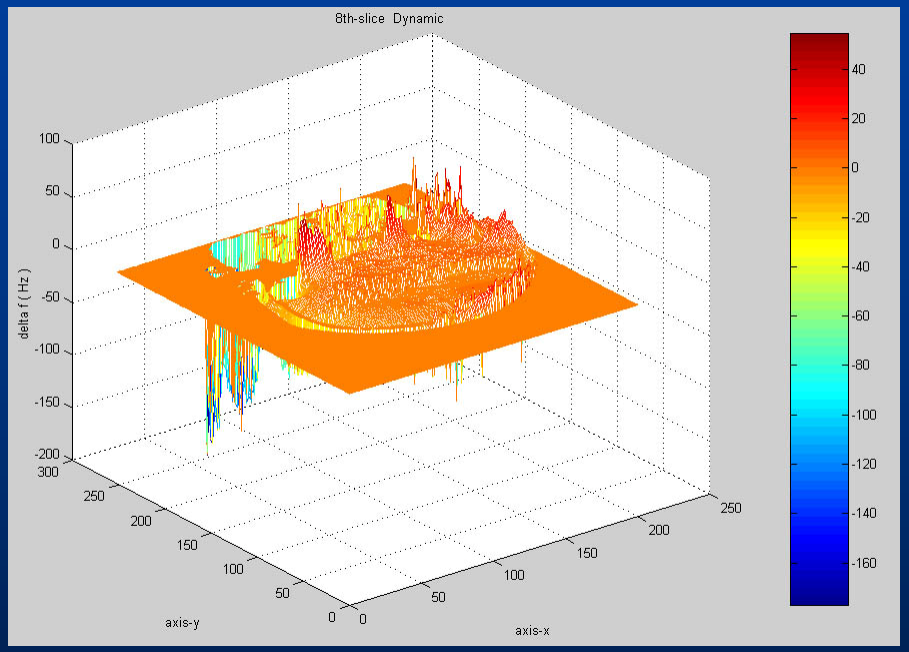
MRI/MRS - Sensors

- 1980 = 4 MHz 2003 = 400 MHz
- Prediction - push to higher field will continue despite costs, engineering problems
- Need “sensors” at high field - RF coils
  - High field arrays; local coils inc. gradients
  - Catheter and endoscopic coils
  - Coils combined with e.g. optical sensors
- System designs to reduce susceptibility effects - e.g. dynamic shimming

Dynamic Shimming



Field plot in brain slice
- global shimming

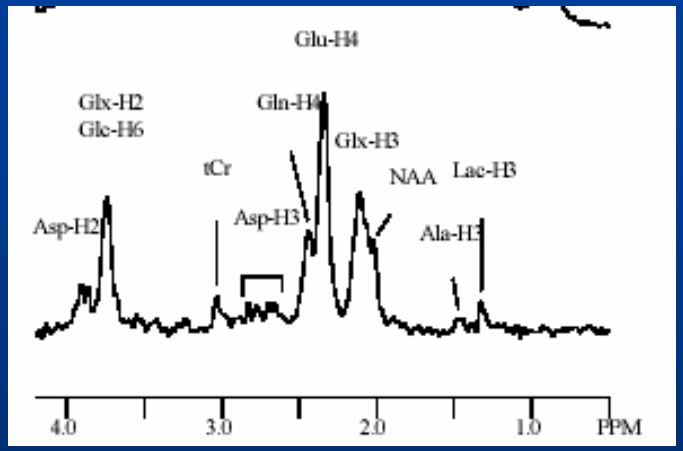


Field plot in brain slice
- dynamic slice shimming

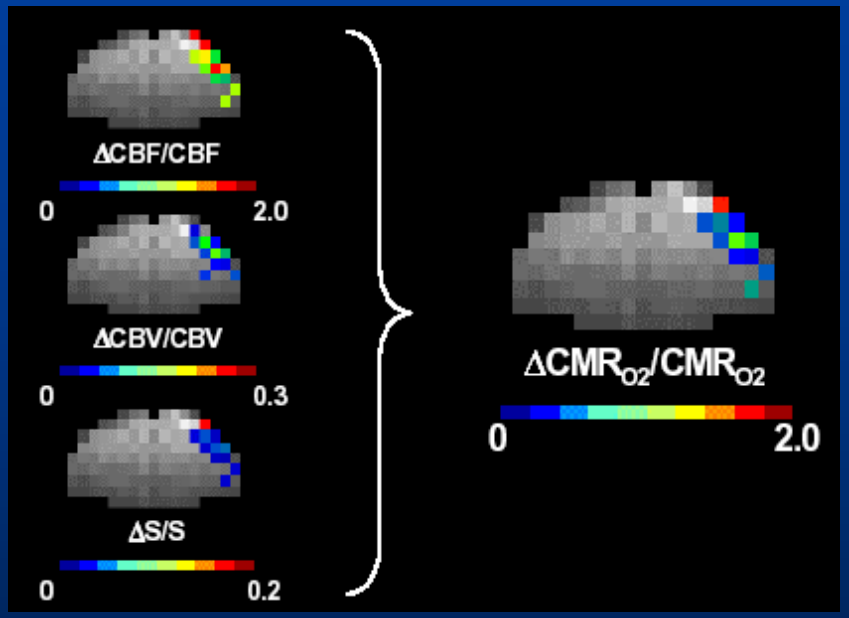
Higher field

- Higher SNR
- Higher resolution
- Faster
- Greater spectral dispersion for MRS
  - *"MRS is the method of the future and always will be"*
  - New reality at higher fields
- Different contrast mechanisms dominate
  - E.g. Chemical exchange - CEST agents - BOLD - etc.

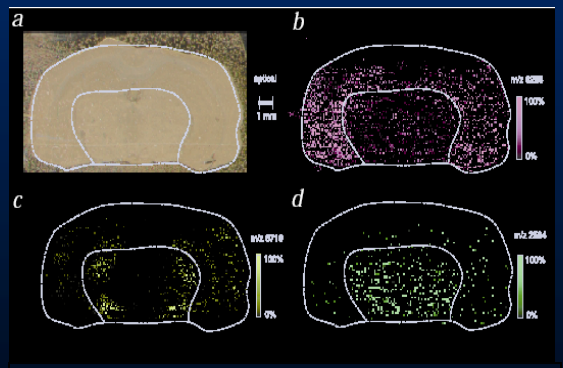
MRI / MRS / MASS SPEC Integration



Proton spectrum at 7T from 100 μL volume



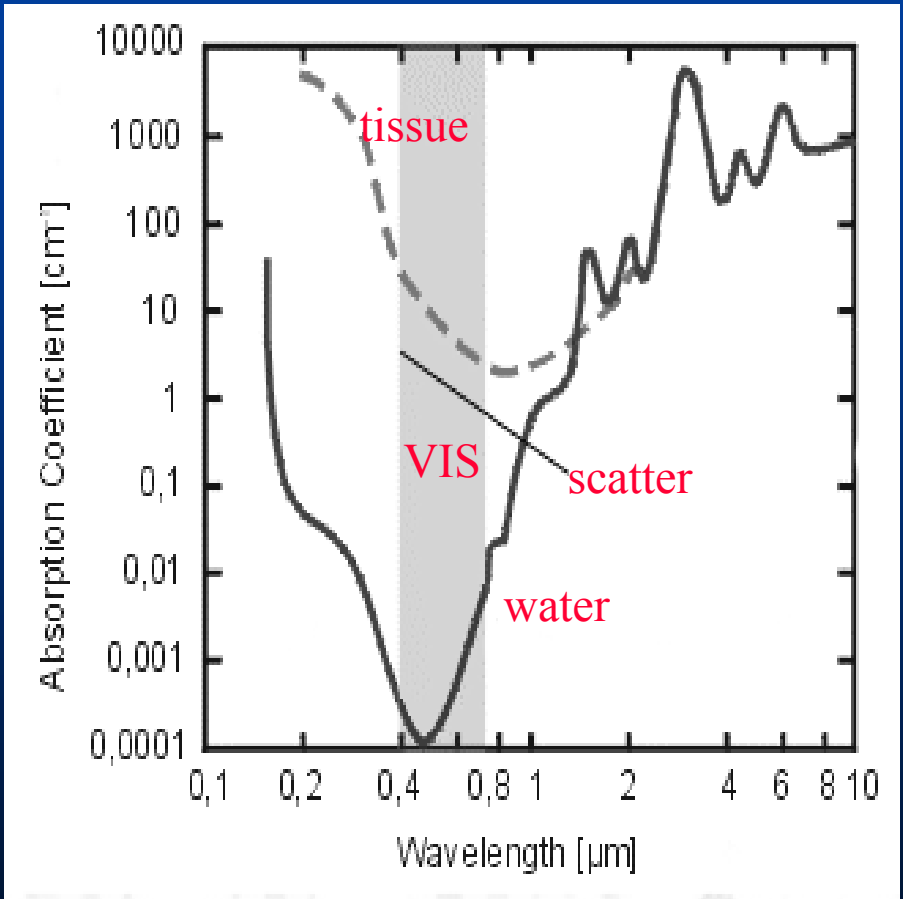
Functional Imaging at 7T



MALDI TOF MS
- 3 different MW

Data courtesy D. Rothman, R. Caprioli

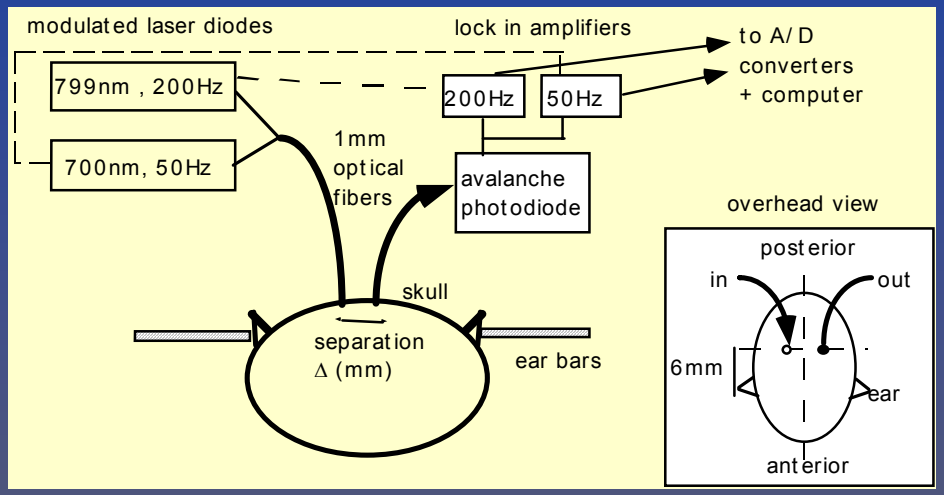
Optical + NIR Imaging

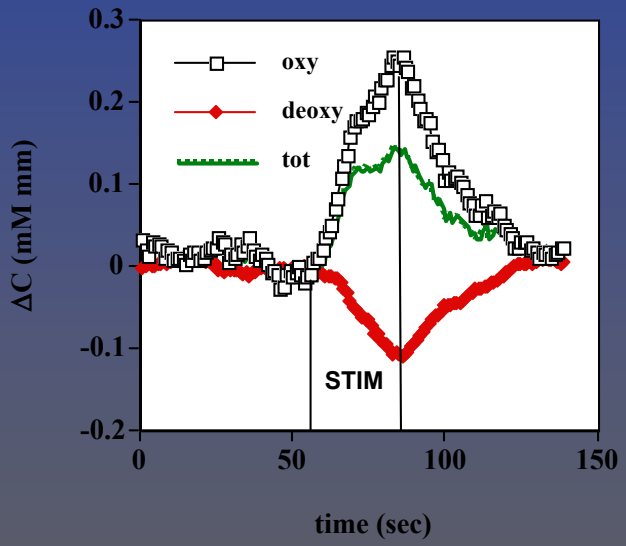


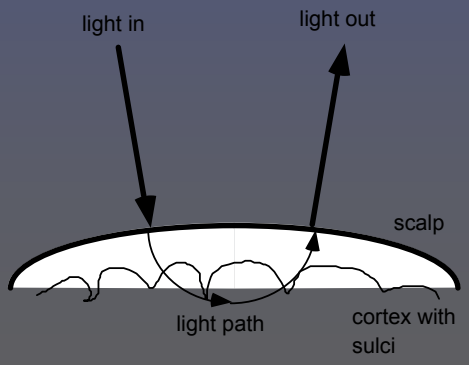
Wavelength dependence of absorption by water and tissue

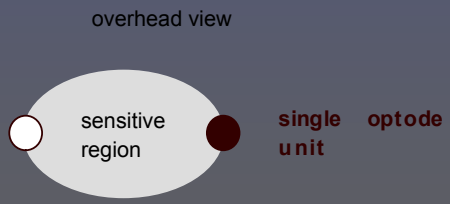
- Tissue minimum≈820 nm
- NIR Microscopic imaging (e.g. 2-photon confocal) possible in mice (>1cm)
- NIR fluorophores for molecular targeting

NIR detection of cortical flow and oxygenation

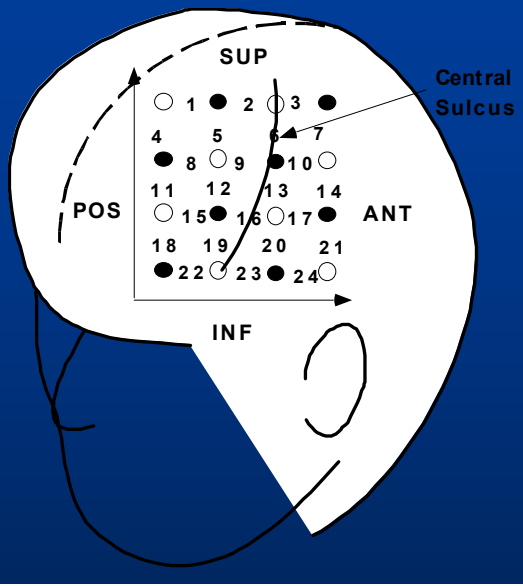


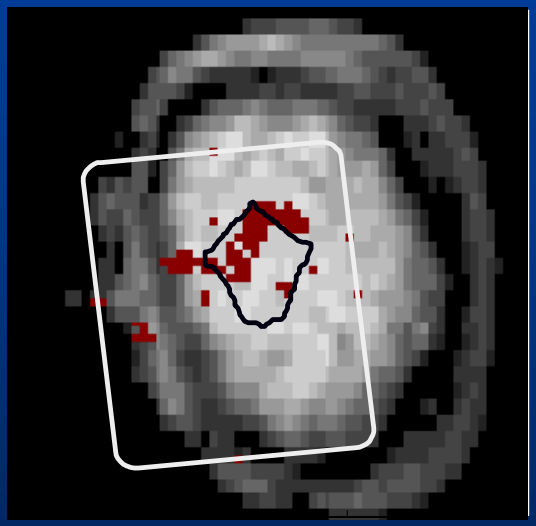




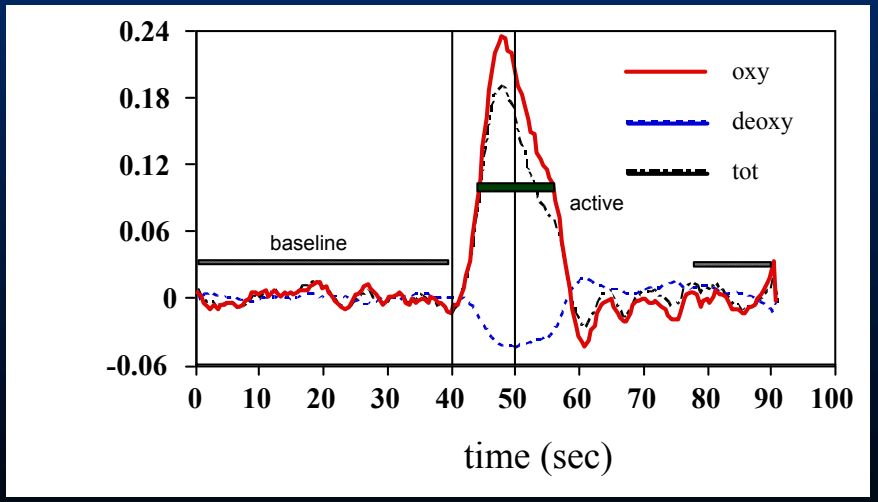


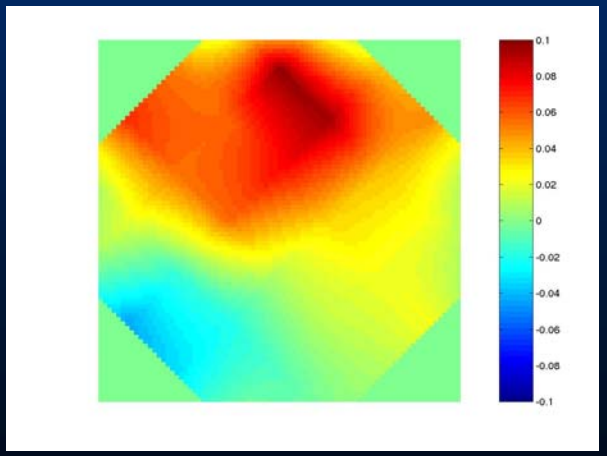
Near Infra Red Tomography





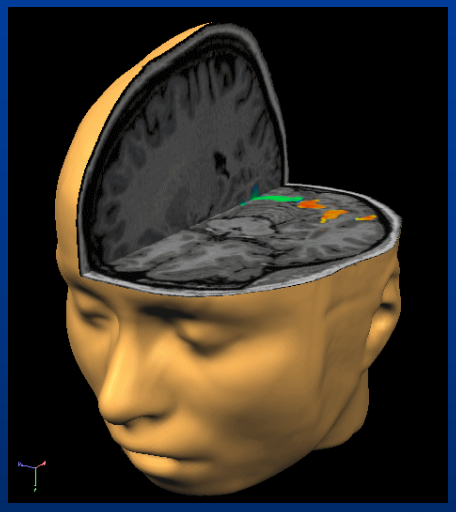
fMRI
+
NIR

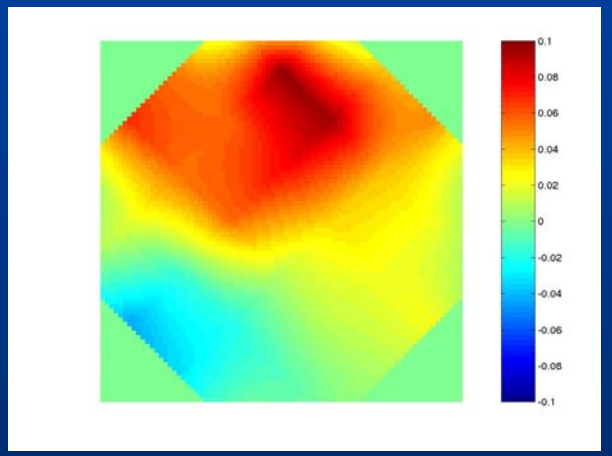


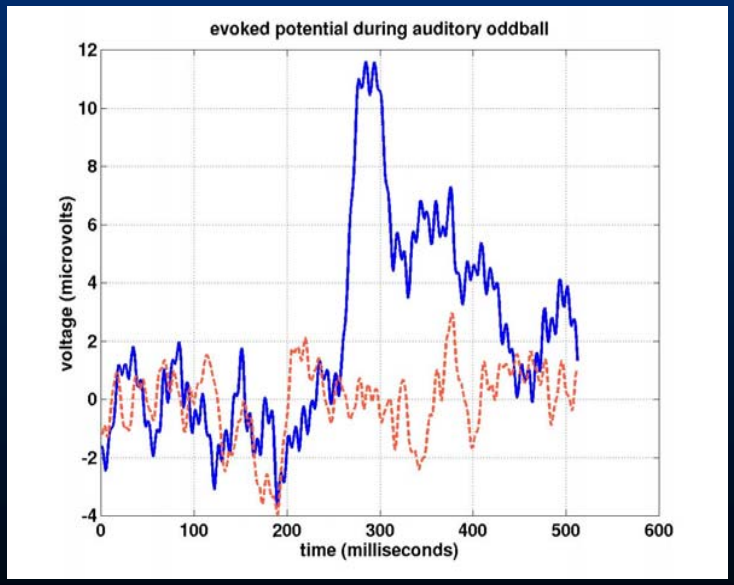


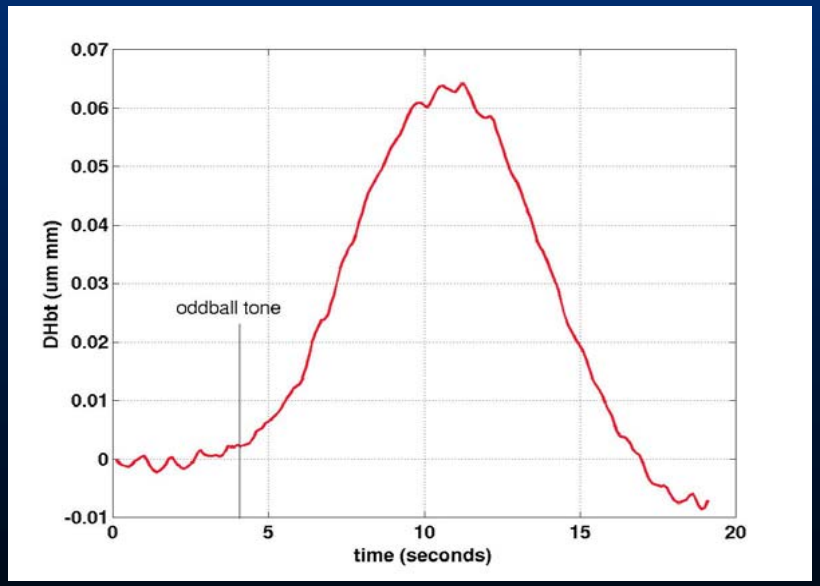
NIR
surface
map

Integration e.g.
NIROT + ERP + TMS + fMRI

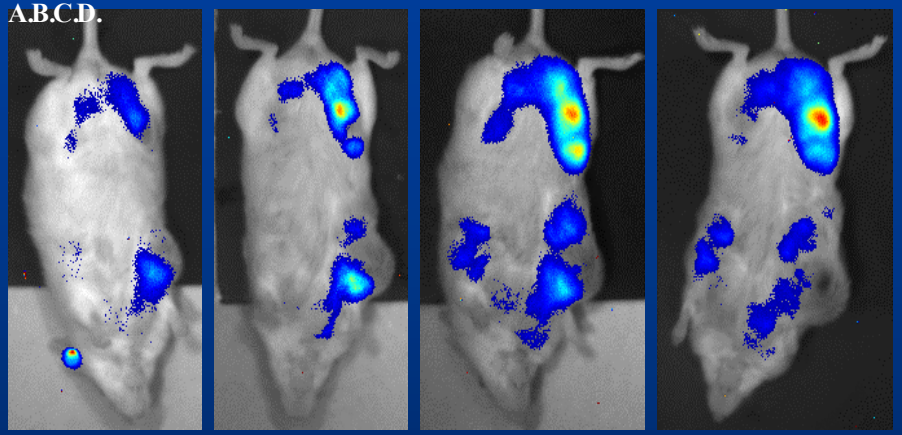


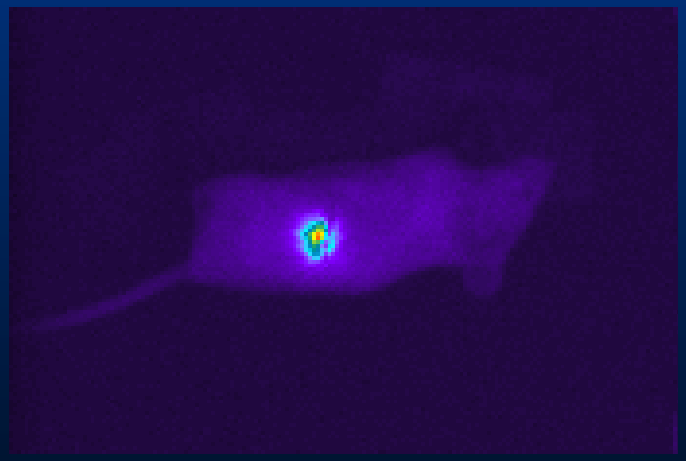






Bioluminescent Imaging





- Bioluminescent imaging (e.g. luciferase) sensitive to molecular and cellular processes
- Links imaging to molecular biology
- Tomographic imaging possible ?
- Combine with MRI, other modalities

Images courtesy Duco Jansen

Summary

- MRI
  - New techniques/technology
  - Understanding the origins of image information
- Optical
- Image fusion